

## **2.0. DESCRIPTION OF BAND SEGMENTATION SHARING**

A band segmentation approach to sharing the MSS frequencies requires that: (1) each system is authorized to operate in some segment of the 1610-1626.5 MHz band,<sup>3</sup> which might or might not be an exclusive spectrum assignment; and (2) criteria are established for assigning spectrum segments to each authorized system. The following is a description of the band segmentation options considered by Drafting Group B.

### **2.1. Motorola's Band Segmentation Plan**

Motorola has proposed a plan for segmenting the 16.5 MHz of uplink spectrum into two 8.25 MHz wide sub-band segments based on access technology (IWG1-3, IWG-34). This band segmentation proposal relates to the uplink. Motorola takes no position as to how the S-band downlink should be shared. The basic elements of this plan for domestic implementation are as follows:

- (1) All qualified applicants would receive a permit to construct systems that can operate over both bands in their entirety (i.e., up to 33 MHz), or as much thereof as they have requested in their applications.
- (2) The first operational system would be permitted to use both bands in their entirety in the U.S., or as much thereof as it has been authorized to use. A system would be considered "operational" when it commences providing commercial MSS services authorized by the Commission.

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<sup>3</sup> The band segmentation options considered here involve assignments only in L-band; it is anticipated that CDMA systems transmitting downlinks in S-band would operate in that band on the basis of full band interference sharing. It was also assumed for the description in this section that the entire 16.5 MHz of L-band was usable for MSS uplinks.

- (3) If two systems become operational and both employ the same access technique, they would coordinate use of the uplink band with each other as follows:
  - (a) If both are FDMA/TDMA systems on the uplink, they would share the 16.5 MHz (or the top 10.5 MHz if both are bi-directional) through "dynamic sharing" (see below) or some other coordinated approach. If one of these systems is not operating on a bi-directional basis, its initial allocation would be in the lower portion of the band.
  - (b) If both are CDMA systems on the uplink, they would share the 16.5 MHz through "interference sharing" in the manner proposed by the CDMA applicants.
- (4) If two systems become operational and employ different access techniques, the uplink band would be partitioned into two equal sections as follows:
  - (a) The FDMA/TDMA system would operate in the upper half of the band (1618.25-1626.5 MHz). This assignment is made because (i) an allocation for bi-directional operations has been proposed for this band, (ii) EIRP density limits are sufficiently high, and (iii) co-frequency, co-coverage sharing is not feasible with existing users such as the Radio Astronomy Service in the lower portion of the band.
  - (b) The CDMA system would operate in the lower half of the band (1610-1618.25 MHz).
- (5) If three or more systems become operational and all systems employ the same access technique, they would coordinate use of the uplink band as follows:
  - (a) If all are FDMA/TDMA systems, they would share the entire uplink band (or the top 10.5 MHz if all are bi-directional systems) through dynamic sharing or some other coordinated

approach. If one of these systems is not operating on a bi-directional basis, its initial allocation would be in the lower portion of the band.

- (b) If all are CDMA systems, they would share the entire uplink band through interference sharing.
- (6) If three or more systems become operational and at least one employs a different access technique than the others, the uplink band would be partitioned into two equal sections as follows.
  - (a) FDMA/TDMA systems would share the 1618.25-1626.5 MHz portion of the band through dynamic sharing or some other coordinated approach. See item 4(a) above.
  - (b) CDMA systems would share the 1610-1618.25 MHz portion of the band through interference sharing.
- (7) Under dynamic sharing, the FDMA/TDMA segment of the band would be partitioned among the FDMA/TDMA systems, with bi-directional systems being assigned spectrum at the top half of the band. Initial assignments would be coordinated between licensees with an understanding that new entrants would receive sufficient spectrum to begin operation. The amount of spectrum assigned to each system would be periodically adjusted (e.g., every three months) in accordance with the traffic demand of each system in the United States. The periodic adjustment of the FDMA/TDMA partition(s) would be based on both originating and terminating billed minutes of use in the United States in accordance with the following formula:<sup>4</sup>

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<sup>4</sup> Billed minutes of use information should be readily available because every system operator will have to keep these data for billing purposes. If a system leases capacity on a private line basis, a modified dynamic sharing methodology would be applicable. Any disputes involving the adjustment of band segments could be resolved in accordance with procedures established by the FDMA/TDMA licensees (e.g., independent arbitrator). Thus, the Commission's role in this process would be limited to approving the ground rules for partitioning of the FDMA/TDMA spectrum.

Allocated Bandwidth - Per System	Billed Minutes of Use Per System	X	Total FDMA/TDMA Bandwidth (MHz) Available
	Sum of All Billed Minutes of Use for All Systems		

The foregoing description of Motorola's proposed band segmentation plan is illustrated in Figures 1-5.

## **2.2 Band Segmentation by Number of Applicants (Licensees)**

IWG1-51 discusses another method of band segmentation, i.e., by number of applicants (licensees). This approach would divide the entire 16.5 MHz uplink band equally between the number of current applicants or licensees ( $1/n$ ) or between current licensees and possible future applicants ( $1/n+1$ ). Under the  $1/n$  approach, since there are six applicants in the current case, each would be assigned 2.75 MHz of spectrum (assuming each receives licensing and construction authority from the FCC). If a future system were to be licensed, several methods for apportioning the previously assigned spectrum could be followed. For example, each of the initial six licensees could be required to surrender a proportional amount of spectrum to the newcomer. An alternative would be to determine which of the initial licensees were not utilizing the spectrum assigned to its full capacity and require only those licensees to contribute their unused spectrum to the newcomer. Yet another approach would be to require the newcomer to wait until one of the initial licensees were to fail or surrender its spectrum before any spectrum would be assigned to it.

As an extension to this approach, and to accommodate new entrants more readily, systems that are capable of doing so may be permitted or required to share on an interference basis by aggregating their assigned segments and jointly operating within the aggregated sub-bands. This, however, would require only those systems that can share on a full band interference basis to provide spectrum to newcomers, effectively leaving the exclusivity granted to the FDMA/TDMA systems intact. See

Figure 6.

### **2.3 Band Segmentation by Channelization**

Under this approach, also discussed in IWG1-51, the entire 16.5 MHz uplink band would be divided into a fixed number of channels with potentially both initial and traffic growth assignments. For example, the band could be standardized on the existing terrestrial cellular channelization scheme and thus divided into thirteen (13) 1.25 MHz channels. Each licensee could initially be assigned one channel each in the upper and lower portions of the band. Also, to maximize sharing, those channels assigned to CDMA licensees could be aggregated and shared on a full band interference basis. Channels not initially assigned to licensees would be reserved for growth of licensed systems and/or possible newcomers. See Figure 7.

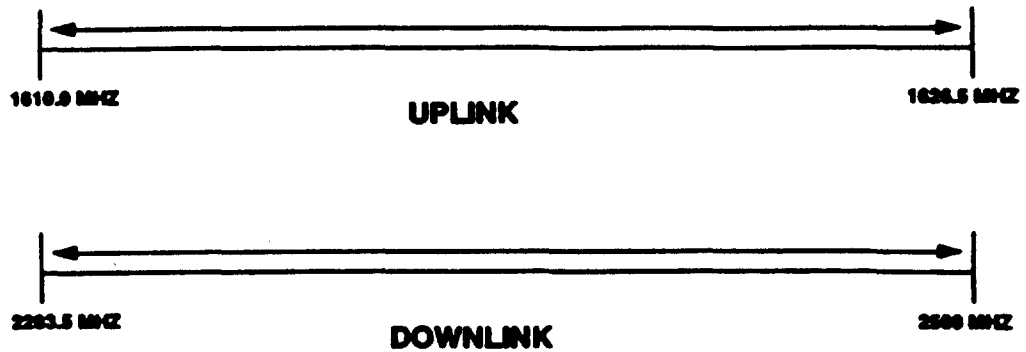
### **2.4 Band Segmentation by Dynamic Band Sharing**

Spectrum is assigned on a dynamic basis. As systems are licensed and come on line, the band is loaded and spectrum assigned in specific accordance with individual system requirements and anticipated demand experience at the time of spectrum assignment. There would be no predetermined sub-bands or channelization schemes. See Figure 8.

FIGURE 1.

## MULTIPLE ENTRY SPECTRUM SHARING

### o SINGLE SYSTEM OPERATION (CDMA)

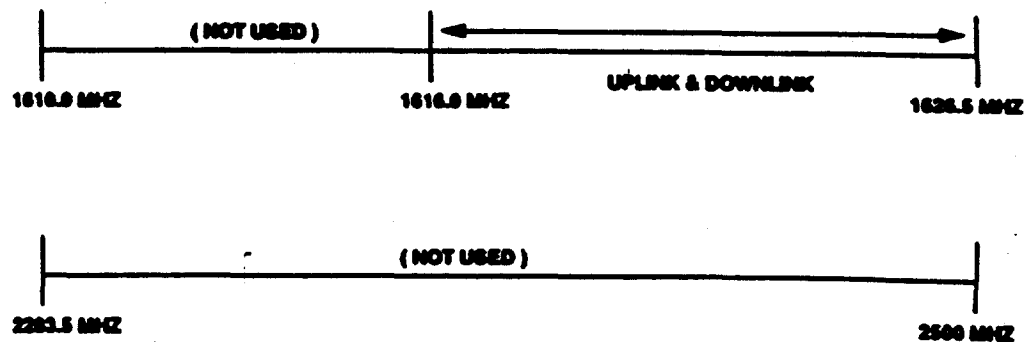


TOTAL BANDWIDTH USED: 33 MHZ

FIGURE 2

## MULTIPLE ENTRY SPECTRUM SHARING

### o SINGLE SYSTEM OPERATION ( FDMA - BiDirectional )

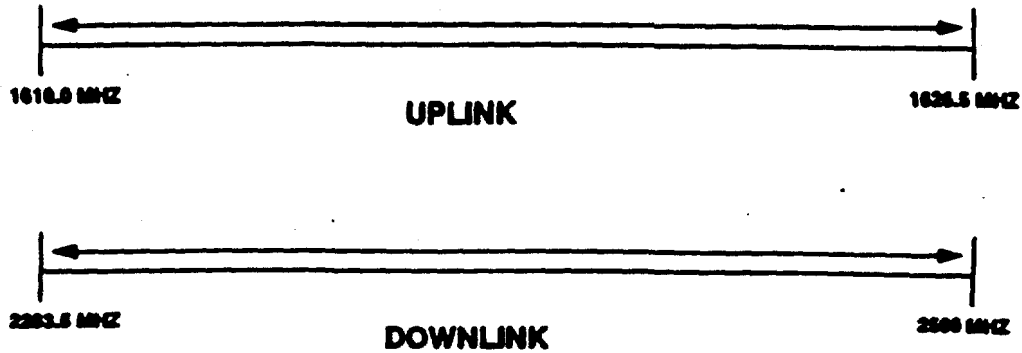


TOTAL BANDWIDTH USED: 10.5 MHZ

FIGURE 3

## MULTIPLE ENTRY SPECTRUM SHARING

o FIRST TWO OPERATIONAL SYSTEMS ARE CDMA

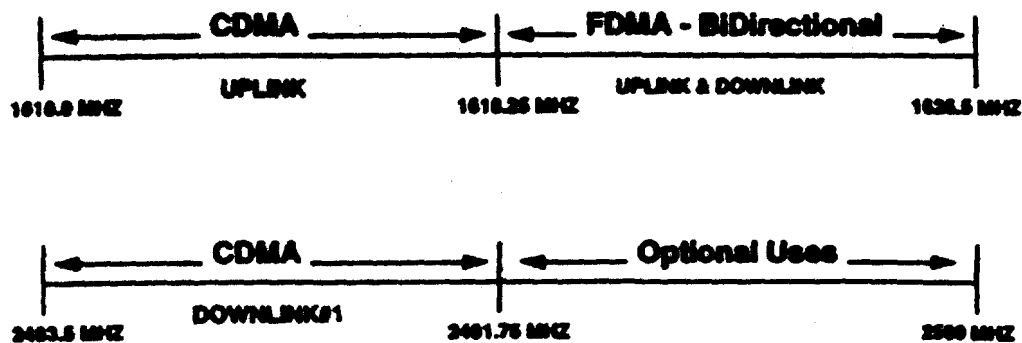


TOTAL BANDWIDTH USED: 33 MHZ

FIGURE 4

## MULTIPLE ENTRY SPECTRUM SHARING

o FIRST TWO OPERATIONAL SYSTEMS  
ARE CDMA & FDMA-BI Directional

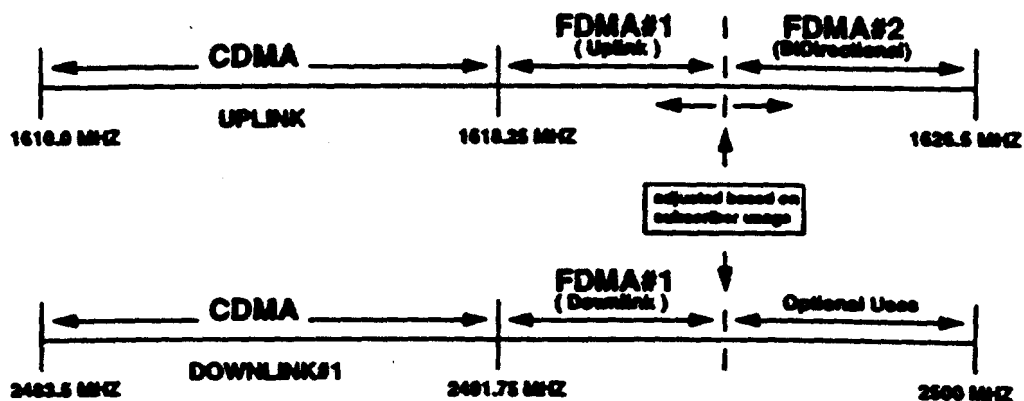


TOTAL BANDWIDTH USED: IFDMA - 8.25 MHZ  
CDMA - 16.5 MHZ

FIGURE 5

## MULTIPLE SYSTEMS / DYNAMIC SHARING

- o FIRST THREE OPERATIONAL SYSTEMS ARE: ONE CDMA, ONE Dual Band FDMA, AND ONE FDMA - BI Directional



TOTAL BANDWIDTH USED: CDMA - 16.5 MHz  
FDMA's - Based on usage

FIGURE 6

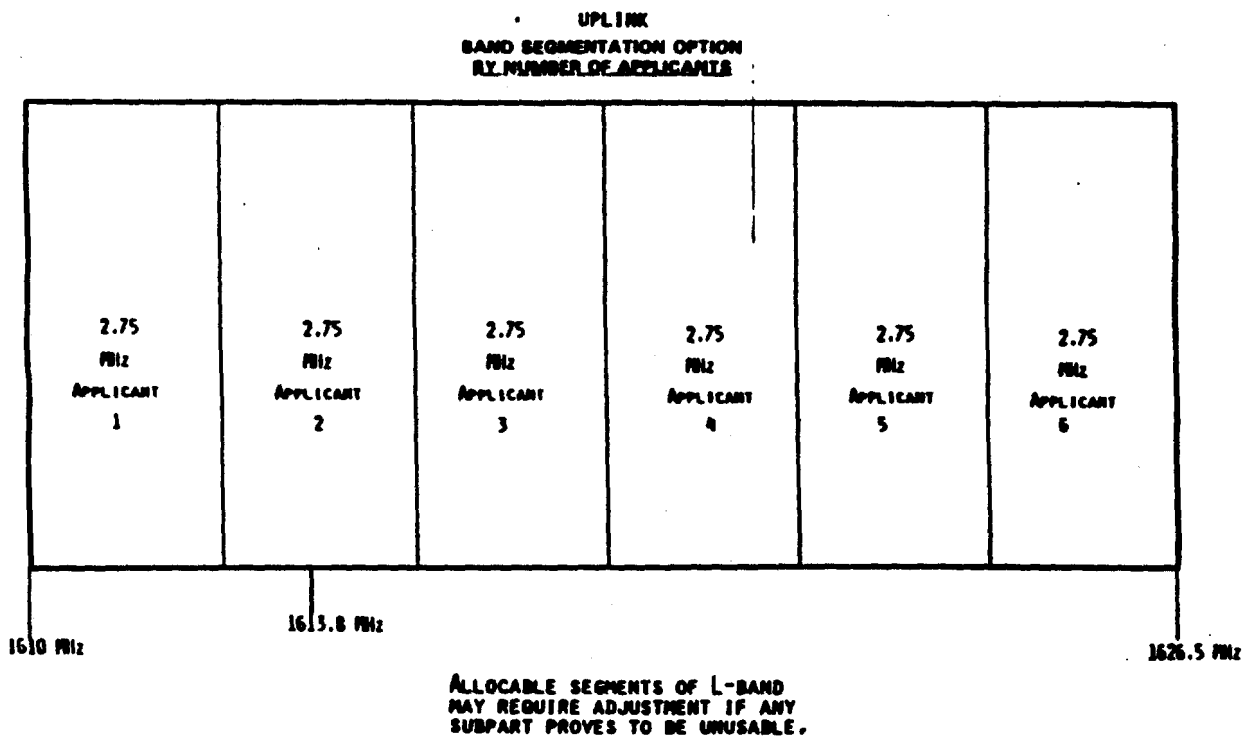




FIGURE 7

UPLINK  
BAND SEGMENTATION OPTION  
CHANNELIZATION

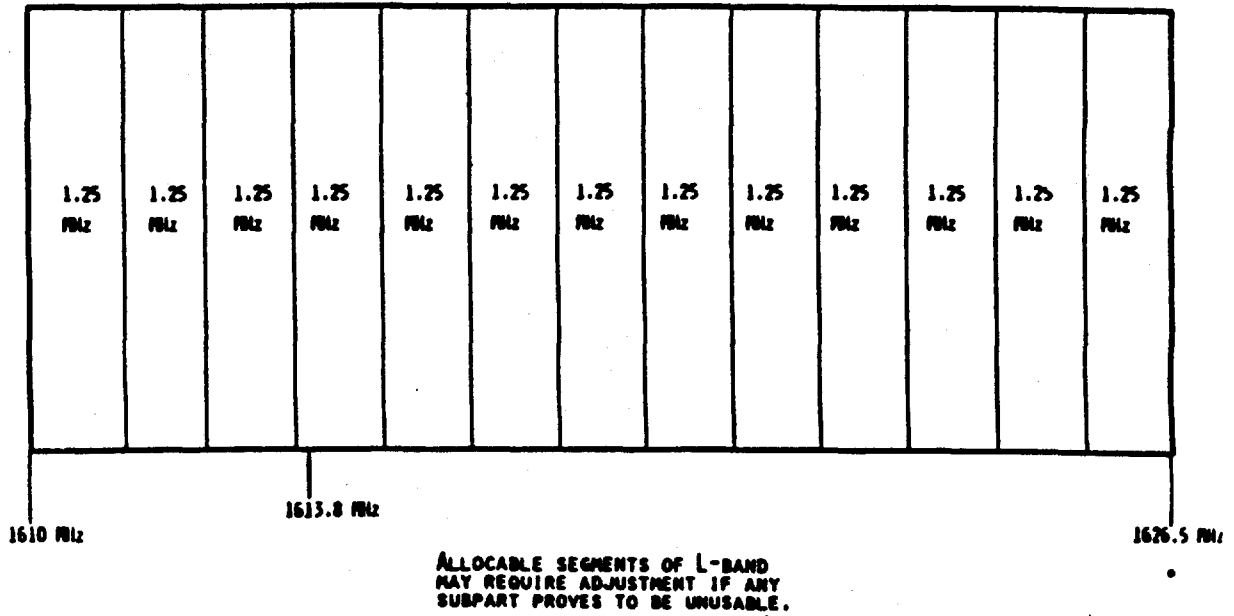
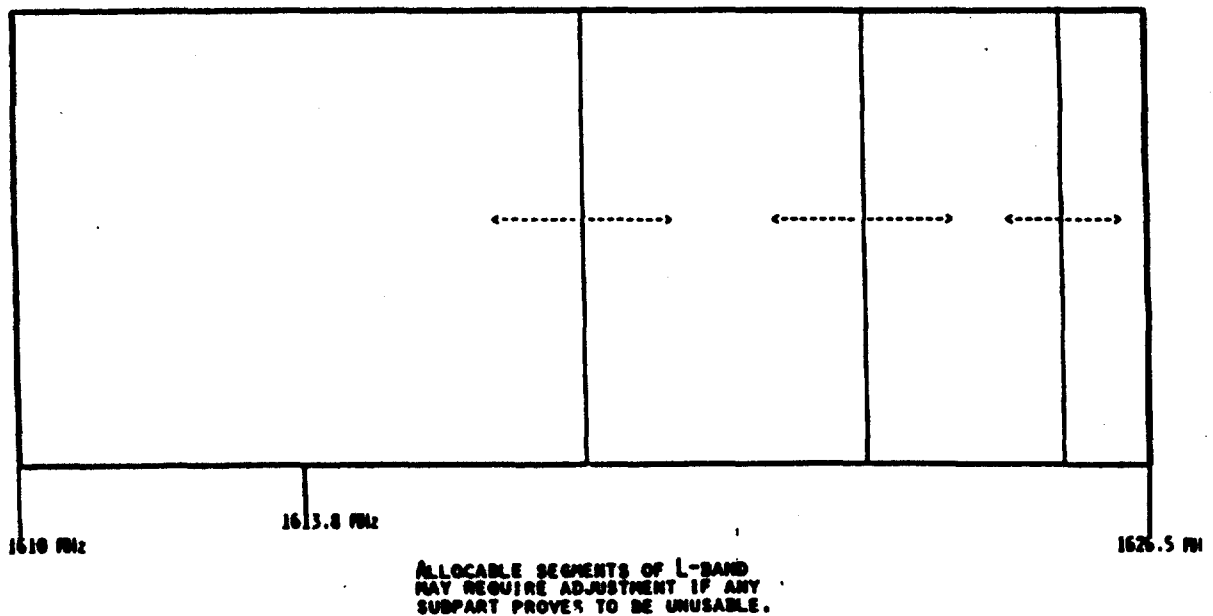


FIGURE 8

UPLINK  
BAND SEGMENTATION OPTION  
DYNAMIC



### **3.0 TECHNICAL SHARING CRITERIA**

The out-of-band emissions rule currently found in Section 25.202(f) should be updated to reflect the operation of MSS systems. It is proposed that Section 25.202 be amended to specify a power spectral density (PSD) mask measured relative to the average in-band PSD at the maximum design power setting for the 1610-1626.5 MHz and 2483.5-2500 MHz bands.

The following is a discussion of why the current rule should be amended. The proposed systems have varying bandwidths and modulation types. Amending Section 25.202 to specify a PSD mask will protect other services and other MSS systems from the sum of the out-of-band emissions from many overlapping CDMA carriers or multiple side-by-side FDMA/TDMA carriers. The current rule specifies the out-of-band PSD relative to the transmitter carrier power. This rule does not adequately account for multiple carriers. A PSD mask can also more adequately be applied to systems with varying bandwidths.

Each system in the MSS bands should be protected from the other systems to a reasonable level. The proposed rules specify emission limits in terms of out-of-band PSD relative to in-band PSD across the CDMA to FDMA/TDMA band segment. This will control interference between dissimilar system types. This proposed rule provides adequate protection from the emissions of the uplinks of a large number of mobile units.

The recommended integration (reference) bandwidth is either 3 kHz or 4 kHz. A 3 kHz integration bandwidth is available on standard test equipment which will simplify measurement. A 4 kHz bandwidth matches previous practice and is in common use. Since the recommended rules are based on a PSD mask, the exact bandwidth of the measurement is not important.

### 3.1 Uplink Out-of-Band Emissions Limits

#### 3.1.1 General Limits

Table 3-1 contains the proposed uplink out-of-band emissions limits. The table delineates a power spectral density (PSD) mask which, in part, protects FDMA/TDMA or CDMA receiving satellites from emissions from numerous mobile units in other frequency channels transmitting CDMA or FDMA/TDMA signals. The mask also provides protection to services out of the MSS uplink band.

Table 3-1

#### FDMA/TDMA and CDMA Uplink Out-of-Band Emissions Limits

<u>Attenuation<sup>5</sup> (dB)</u>	<u>Frequency Separation<sup>6</sup></u>
26	$>0.5b + r/2$ through $1.5b^7$
38	$>1.5b$ through $2.5b$
45	$>2.5b$

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<sup>5</sup> "Attenuation" is the attenuation of the average out-of-band emissions power measured in a reference bandwidth,  $r$ , relative to the average over the authorized bandwidth in-band power measured in the reference bandwidth. The attenuation levels define a power spectral density mask. The transmitter power level should be set to the maximum design power and loading.

<sup>6</sup> The "Frequency Separation" is the frequency difference between the assigned frequency and the center frequency of the reference measurement bandwidth.

<sup>7</sup> The "authorized bandwidth",  $b$ , is the larger of the occupied bandwidth (the 99% power bandwidth) or the necessary bandwidth of the transmitted signal.

The measurement methodology must be based on average power measurements at the maximum design power settings. In the event that out-of-band emission levels are shown to be below measurable amounts equal to the background noise level of reasonably sensitive test equipment, then the above attenuation levels are considered satisfied by out-of-band emissions which are under the noise floor.

In the event that the out-of-band PSD mask in Table 3-1 is not met, a waiver to this mask may be allowed if there is a showing that the operation of the equipment will not cause harmful interference to other systems or services or if it is shown that the out-of-band PSD is below an interference level coordinated with potentially interfered-with systems (as referred to in section 3.1.2).

### **3.1.2 Emission Limitations Between Band Segments**

A limitation on the out-of-band-segment emissions needs to be established to minimize the intersystem interference between systems operating in different segments of the spectrum in a band segmentation approach. The amount of isolation that is required between the band segments will be dependent on the number of systems that are operating and other system parameters. At this point in time it is premature to specify a fixed isolation number, since the total number of foreign and domestic systems that will be operating in the vicinity of the U.S. is unknown. Currently a 45 dB isolation is proposed for good protection between an FDMA/TDMA system and a CDMA system or systems that are operating at or near capacity. This assumes representative design parameters for the systems. An isolation number like this will be the subject of coordination among the system operators and will dictate the amount of guardband, if any, required from the edge of the band to the carrier frequency of the nearest channels of the FDMA and the CDMA systems.

### **3.2 Downlink Out-of-Band Emissions Limits**

Table 3-2 contains the proposed downlink out-of-band emissions limits. The table delineates a power spectral density (PSD) mask which protects FDMA/TDMA or CDMA receiving mobile units from emissions from

satellite downlinks in another band within the 2483.5-2500 MHz band or within the 1613.8-1626.5 MHz secondary downlink band. The mask protects MSS uplinks from out-of-band emissions from a secondary downlink in the 1613.8-1626.5 MHz band. The mask also provides protection to other systems operating out of the MSS bands. This table need not apply within the CDMA band segment, where the out-of-band emissions can be the subject of coordination.

Table 3-2

FDMA/TDMA and CDMA Downlink Out-of-Band  
Emissions Limits to Protect Other MSS Downlinks

<u>Attenuation<sup>8</sup> (dB)</u>	<u>Frequency Separation<sup>9</sup></u>
25	$>0.5b + r/2$ through $1.5b^{10}$
35	$>1.5b$ through $3.0b$
43	$>3.0b$

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<sup>8</sup> "Attenuation" is the attenuation of the average out-of-band emissions power measured in a reference bandwidth,  $r$ , relative to the average over the authorized bandwidth in-band power measured in the reference bandwidth. The attenuation levels define a power spectral density mask. The transmitter power level should be set to the maximum design power and loading.

<sup>9</sup> The "Frequency Separation" is the frequency difference between the assigned frequency and the center frequency of the reference bandwidth.

<sup>10</sup> The "authorized bandwidth,"  $b$ , is the larger of the occupied bandwidth (the 99% power bandwidth) or the necessary bandwidth of the transmitter signal.

## **4.0 OPERATING CONDITIONS AND CRITERIA NECESSARY TO PROTECT PRIMARY UPLINKS FROM SECONDARY DOWNLINKS**

### **4.1 Introduction**

This section discusses the potential for interference to primary MSS uplinks in the 1610-1626.5 MHz band from secondary downlinks in the 1613.8-1626.5 MHz band, calculates interference levels into representative systems from the Iridium system downlinks, and identifies possible methods to mitigate any interference to non-harmful levels.

Potential in-band interference occurs when an Iridium system downlink transmits Line of Sight (LOS) into a satellite of another MSS system due to full or partial co-frequency operation with the primary uplink of the other system in an adjacent geographic region.

Similarly, the out-of-band noise from an Iridium system downlink could create interference into a primary uplink operating in an adjacent frequency if there is LOS between each satellite's antenna systems.

#### **4.1.1 Limited Geographic Scenarios**

MSS earth terminals are characterized by low gain portable or vehicular antennas transmitting their uplink signals in a near omnidirectional pattern. Licensing the primary uplink frequencies of the terminals is achieved by coordinating uplink operations within large geographic areas to avoid unresolvable uplink interference problems. For example, an MSS system might have a unique frequency band assigned to it for the entire North American continent and a band with some percentage of overlap for operation in the South America continent. It is even possible that the ITU Regions 1, 2, and 3 will each have a unique assigned frequency plan which is consistent throughout each region.

When MSS satellites with FDMA or FDMA/TDMA channels are licensed for uplink operation in the 1610 to 1626.5 MHz band, they must be band segmented from other systems operating in the same geographic coverage areas. Also, when uplinks in different geographic regions are operating partially co-frequency, they must be coordinated to avoid interference

into each system's uplink from the many mobile terminals on the earth.

Some systems, such as Iridium, may operate a secondary downlink in the same frequencies as their primary uplink in a Time Duplexing Mode (TDM). If other systems that operate co-coverage on the earth are not operating co-frequency, then out-of-band emissions from a TDM downlink band might interfere with these uplinks. Since different regions could have overlapping frequency coverage there is the potential for TDM downlinks to transmit into a primary LOS uplink beam in an adjoining region.

The coordination of MSS uplink frequencies between satellite systems of different technologies will limit the geographic area within which such systems could operate with overlapping frequencies. In addition, most MSS satellites will be in a non-synchronous orbital mode and will be in continual relative motion between the satellites. Coupling between satellite beams will therefore vary rapidly with time. Interference between the secondary downlink and the primary uplink can only occur when the path loss is minimal and co-frequency radiated flux densities are sufficiently high.

#### **4.2 Regulatory Background**

WARC-92 allocated the 1610-1626.5 MHz band to the Mobile-Satellite Service (Earth-to-space) on a primary basis in all three ITU Regions. WARC-92 also allocated the 1613.8-1626.5 MHz band to the Mobile-Satellite Service (space-to-Earth) on a secondary basis in all three ITU Regions. Footnote 731Y states: "The use of the band 1613.8-1626.5 MHz by the mobile-satellite service (space-to-Earth) is subject to the application of the coordination and notification procedures set forth in Resolution 46." Footnote 731X includes virtually the same wording in relation to the use of the 1610-1626.5 MHz band for MSS and RDSS Earth-to-space transmissions.

##### **4.2.1 Radio Regulations**

Radio Regulations Article 8, Section II (RR 420 et. seq.) states:

**"Stations of a secondary service:**

- a) shall not cause harmful interference to stations of primary or permitted services to which frequencies are already assigned or to which frequencies may be assigned at a later date;
- b) cannot claim protection from harmful interference from stations of a primary or permitted service to which frequencies are already assigned or may be assigned at a later date;
- c) can claim protection, however, from harmful interference from stations of the same or other secondary service(s) to which frequencies may be assigned at a later date."

Sections 2.104(d)(4) and 2.105(c)(3) of the Commission Rules are identical to Radio Regulations 420 through 423.

#### **4.2.2 Definition of Harmful Interference**

"Harmful interference" has been defined both by the FCC and the International Telecommunication Union (ITU) as follows:

"Interference which endangers the functioning of a radionavigation service or of other safety services or seriously degrades, obstructs or repeatedly interrupts a radiocommunication service operating in accordance with these Radio Regulations"

47 C.F.R. §2.1 (Emphasis added); see also, ITU Radio Regulations Art. 1, §7.4 (¶163).

#### **4.3 Conditions of Interference and the Coordination Process**

The conditions of interference must be included in any analysis of harmful interference. It is relevant to consider the cases of interference between coordinated systems. The coordination process between



licensees involves the consideration of the mechanisms of coupling between interfering transmitters and victim receivers.

The mechanisms of interference are further complicated by the unique characteristics of the proposed MSS systems. Some systems (FDMA/CDMA, sometimes referred to as channelized CDMA) propose to operate on a co-frequency, co-location basis. These systems share accumulated EIRP in the uplink and a system limited PFD in the downlink. Under the interference sharing rules proposed by the CDMA applicants, multiple ground-based transmitters will be operating in the same frequency until a level is reached where the resulting bit error rate becomes excessive for that system.

One system (FDMA/TDMA) will operate bi-directionally, utilizing the same frequencies for uplink and downlink operation. Interference from this system is limited by band segmentation and through the use of TDMA techniques. This system requires a large fade margin and therefore is intolerant to heavy outside interference. Therefore, this system must be band segmented from the FDMA/CDMA systems.

#### **4.3.1     Intra-System Interference**

This section discusses the potential for interference between different satellites of the same satellite system that employs both the secondary downlink and primary uplink in a co-frequency TDD manner. It was noted (in IWG1-25) that inclusion of sufficient time guard bands between receive and transmit bursts would ensure that the Iridium system would not self-jam because the interference mechanisms are entirely predictable -- based on the geometry of the constellation -- and can be avoided by proper design. At worst, the horizon-to-horizon range between Iridium satellites will be 6500 km. However, even under this scenario, the potential interfering downlink source will arrive at the victim satellite during the guard time included in the frame. This guard band is sufficiently wide to protect the victim satellite from the interfering satellite's downlinks during all possible constellation geometries.

#### **4.3.2     Inter-System Interference**

This section discusses the potential for interference between different satellite systems sharing the same frequency band. Figure 4.3-1 shows an example of the ways in which the direct line-of-sight interference mechanism might occur; a single interfering satellite and four possible victim satellites. In reality there might be many interfering and victim satellites, and their position relative to each other will be constantly changing. Each of the four cases of interference is described briefly below:

- Case 1:**     Victim satellite #1 is in a higher orbit than the interfering satellite. The minimum spacing between the satellites will be the difference in orbit altitudes. This distance is only momentary with the distance increasing rapidly. The potential interference is from the backlobe of the interfering satellite into the mainlobe of the victim satellite.
- Case 2:**     Victim satellite #2 is shown to be in an orbit of comparable (but not of close) altitude to that of the interfering satellite. As such there will be times when the interfering and victim satellites may close but this is many times the difference in altitude (see Case 1). In this case, the potential interference is from the sidelobe of the interfering satellite into the sidelobe of the victim satellite. Since Case 1 dominates Case 2, no further analysis will be made.
- Case 3:**     Victim satellite #3 may be in any orbit. The characteristic of this case is that the potential interference path is just over the horizon of the Earth. Therefore the potential interference may be from the greatly attenuated part of the interfering satellite into the greatly attenuated mainlobe or even sidelobe of the victim satellite. The worst scenario occurs when the satellite tips its main beam to the horizon. The effect of antenna gains are further reduced by the longer link distances involved.

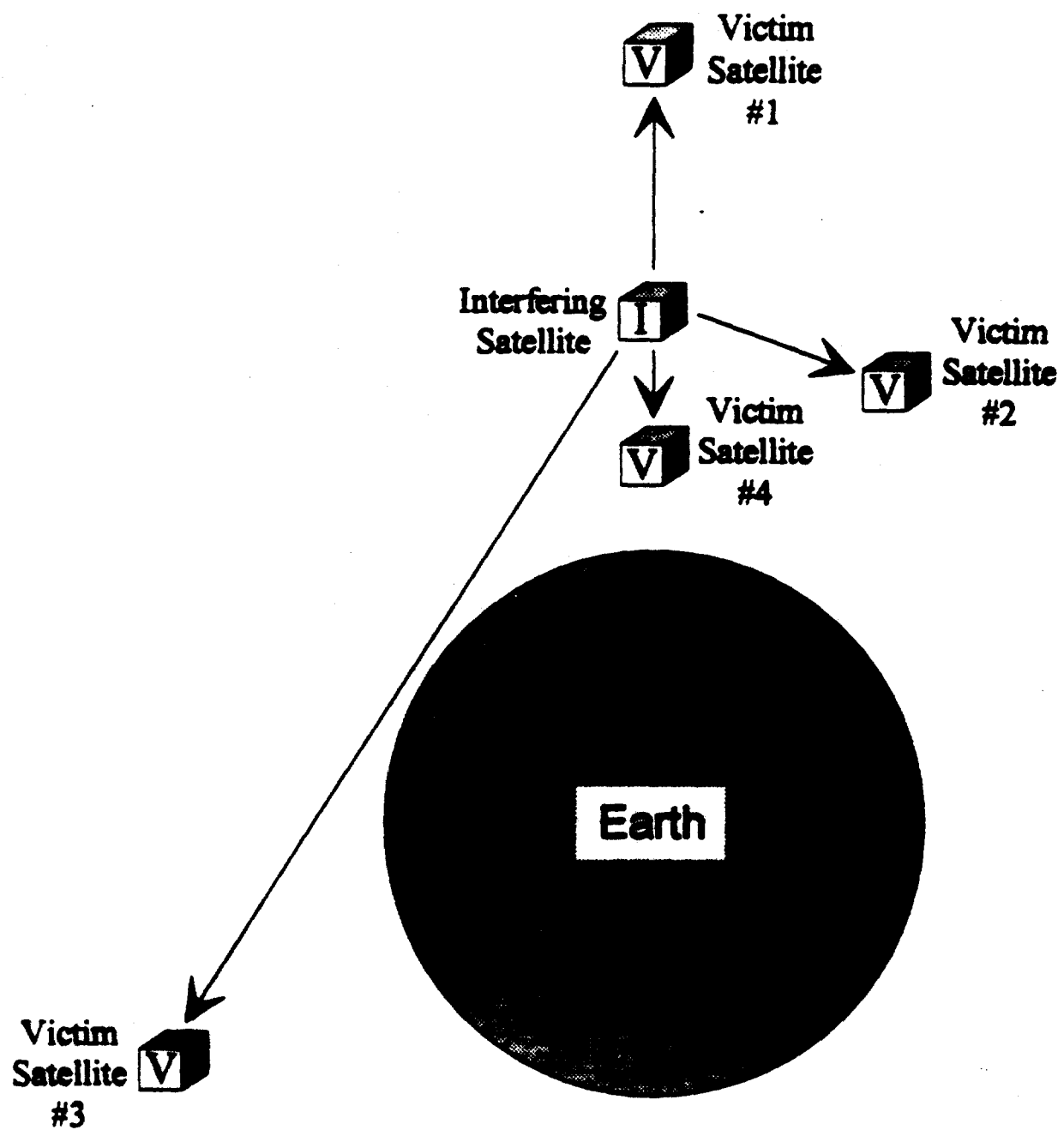


Figure 4.3-1 - Interference Mechanisms

**Case 4:** Victim satellite #4 is in a lower orbit than the interfering satellite. Only the Ellipso system has proposed a lower orbit than the Iridium system. The low point in the Ellipso orbit occurs outside its service area due to the poor coverage by the elliptical satellites near perigee.

#### **4.3.2.1 Primary Uplink Interference.**

The Iridium system transmits and receives over the same frequency. When one (or more) MSS systems are operating co-frequency with the Iridium system and the beam coverages from the two systems overlap on the Earth, both systems typically will receive uplink signals from the subscriber units in all co-coverage areas.

On occasion, the other system (System B) may also receive the Iridium downlink signals from the backlobe or sidelobe of the Iridium satellite. This downlink signal will be of a lesser magnitude than the uplink signal and therefore will be dominated by the uplink signal.

Figure 4.3-2 illustrates this scenario. In this example, the System B satellite and the Iridium satellite are orbiting at an altitude of 1414 kilometers (km) and 780 km, respectively. The altitude of 1414 km was chosen for this analysis since it corresponds to the approximate altitude of one of the MSS applicants (Globalstar). The System B satellites are receiving signals from both the Iridium subscriber units (ISU's) and from the Iridium satellite through its backlobes.

There may be several Iridium satellite beams in one beam of System B. There also may be more than one Iridium user terminal transmitting on a given frequency at any one time within the System B beam. However, in the most conservative case only one ISU is assumed to be transmitting with an average uplink EIRP of -1.1 dBW. The corresponding transmitted power spectral density (PSD) is -47.3 dBW/Hz. The received PSD is this value less the space loss (159.5 dB) or -206.8 dBW/Hz. A CDMA receiver will spread this signal and reduce the impact.

Figure 4.3-3 also contains an example of backlobe power. The downlink power from the satellite is an aggregate peak average of 19.2



dBW maximum per channel or -27.0 dBW/Hz. Taking voice activity and 6 times frequency reuse into account, the downlink EIRP density (DP) becomes -23.5 dBW/Hz. Assuming an Iridium system backlobe gain of -39 dB relative to the downlink EIRP, the backlobe power (BP) becomes -62.5 dBW/Hz. The received power is this value less the space loss of 152.7 dB (634 km) or -215.2 dBW/Hz. This interference level is clearly much less than that of the uplink.

#### **4.3.2.2 Downlink Reflections from the Earth**

This interference scenario is evaluated by using the ELLIPSO System for illustrative purpose. The primary interference path is the uplink path to the ELLIPSO satellite from Iridium subscriber units. The ELLIPSO subscriber unit produces a PFD of -199.9 dBW/m<sup>2</sup>/Hz at the ELLIPSO satellite. The Iridium subscriber unit is capable of producing an effective PFD of -243.3 dBW/m<sup>2</sup>/Hz when demodulator spreading is considered. An assemblage of IRIDIUM subscribers which fully loads a single ELLIPSO channel could increase the PFD at an ELLIPSO satellite to approximately -226.0 dBW/m<sup>2</sup>/Hz. Calculations to support these PFDs are contained in Annex 4.4 of this report.

A second downlink interference path is earth surface reflections of energy from an Iridium satellite beam back to an ELLIPSO satellite antenna. While an infrequent event of lesser magnitude, the subject is evaluated in Annex 4.4 of this paper.

A reflection path between an Iridium satellite and an ELLIPSO satellite is complex. The geometry of the two satellites must be considered as well as the statistical properties of the reflected signal. Considering first the properties of the earth as a reflector, a number of investigators have shown that the earth is rough at L-Band (see Appendix B of Annex 4.4). Hence the earth acts as a scatterer of radiation more so than a spectral mirror. The loss figure typically used for diffuse scattering is -10 dB. To this figure must be added at least another -3.0 dB to account for beam divergence. These values apply at all times over land surfaces and 99+% of the time for large bodies of water. A large body of water the size of Lake Superior needs to have wave heights of less than a few centimeters to be considered a spectral mirror.

The Iridium satellite is capable of producing through out-of-band reflections an effective per channel PFD of  $-245.5 \text{ dBW/m}^2/\text{Hz}$  at the ELLIPSO satellite when demodulator spreading is considered. A set of Iridium subscribers fully loading a single ELLIPSO channel could increase the PFD at an ELLIPSO satellite to approximately  $-228.0 \text{ dBW/m}^2/\text{Hz}$ . Calculations to support these PFDs are contained in Annex 4.4 of this paper.

Harmful interference to the ELLIPSO system begins when the sum of all interference, including self and other system interference, reduces the bit error rate to less than an acceptable level. The ELLIPSO system is portrayed as being able to tolerate many interfering signals, i.e. 15 ELLIPSO equivalent signals, within a channel. This tolerance has a "soft knee" characteristic, i.e., a slight increase in interference causes a slight increase in bit error rate which results in a slight decrease in voice quality. A "hard knee" would require a reduction of channel capacity. Channel capacity reduction is not required by the ELLIPSO system if the increase in bit error rate is minimal.

A fully loaded set of Iridium primary uplinks produces the equivalent of 0.0022 ELLIPSO channels. The corresponding downlink reflections produce the equivalent of 0.0013 ELLIPSO channels. The combination of these signals causes a negligible increase in the ELLIPSO bit error rate.

As long as the Iridium and ELLIPSO systems do not operate on a co-frequency basis, interference to ELLIPSO will be negligible. A band segmentation of frequency assignments between the two systems would permit sharing of the 1616.0 - 1626.5 MHz band.

#### **4.4 Calculations and Criteria for Evaluating the Potential for Interference From Secondary Downlinks**

##### **4.4.1 Background**

This section analyzes the effect of potential interference due to in-band secondary downlinks on the performance of systems with primary CDMA uplinks.

The results of such interference analyses will depend on the specific parameters of the transmissions involved as well as the methods employed to calculate and assess the effect of the interference. In addition, the dynamic and statistical nature of interference involving low-earth-orbit satellites must also be considered.

The interference analyses for this case need to consider two factors not generally included in the usual calculation and assessment of the effect of interference in satellite communications systems. The first new factor is that one or both of the satellites involved in the analysis will not be in a geostationary orbit. Thus, the interference calculations should take into account the variable nature of the interference path lengths, antenna directivity, time duration and probability of interference "events", etc. The second new factor is that the systems involved may employ multiple access to spectrum by means of code division (CDMA). There are neither widely-recognized technical papers nor CCIR reports/recommendations yet available for guidance on the assessment of interference involving use of CDMA in communications satellite systems. In fact, the Appendix 3 and 4 forms used in international satellite coordination, as required by Resolution 46 of WARC-92, do not include all the information needed for interference analyses involving CDMA systems.

It is clear that new, internationally accepted analytical "tools" are needed for the calculation and assessment of interference involving non-geostationary communications satellite systems as well as for systems utilizing CDMA techniques. WARC-92 recognized this problem in Resolution 46 where it stated:

that the coordination methods for non-geostationary satellite networks require specific criteria and calculation methods which are not yet available;

In addition, in Resolution COM5/11, WARC-92 recognized:

...there are no standards governing the coordination, sharing and operation of [low-orbit satellite] systems within the world telecommunications network;



bearing in mind that only a very limited number of low-orbit satellite systems offering worldwide coverage could coexist in any given frequency band;

resolves to invite the organs of the ITU [CCIR and IFRB] ...to carry out, as a matter of priority, technical, regulatory and operational studies to permit the establishment of standards governing the operation of low-orbit satellite systems...

Several methods have been proposed during this proceeding both for calculating interference to CDMA systems, and for establishing criteria on the effect of interference on CDMA system operation. No agreement on a single approach to the evaluation of interference effects has been reached by the MSS applicants.

As noted above, in order to perform a meaningful analysis it is necessary to employ the actual or anticipated transmission parameters of the systems involved. However, the system and transmission characteristics of most of the CDMA applicants are currently in a state of flux. Even during the few months of the negotiated rulemaking process, several CDMA applicants have proposed significant changes to their system designs. For example, one system has proposed to change its maximum orbital altitude from 2200 kilometers to 7800 kilometers, and to employ a different type of equatorial orbit. Others have proposed to double, triple, or quadruple the number of satellite beams covering CONUS, implying a substantial change is also taking place to their satellite antenna gains.

Because of the above cited uncertainties, it is not possible to draw final conclusions from analyses performed at this time. The contents of this section should be considered as an exposition of possible analytical techniques and criteria to be employed. Representative system parameters are used with one of the proposed analytical methods of assessing interference to show the likely maximum impact of the interference cases of primary concern.